NOTES ON THE STRUCTURE OF THE MOTH ATTACUS CECROPIA.

(*Abstract.*)

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In common with other insects of this class, the heart consists of a tube constricted at regular intervals and situated in the median line of the abdomen, above the other organs. Its anterior chamber is prolonged, reaching to the prothorax, where it splits up into several branches. In one specimen examined the aorta did not branch. These branches of the aorta are the only blood vessels that I have succeeded in finding. They are very short and radiate like outspread fingers.

The blood, a light yellowish green fluid, containing oval granular corpuscles, is propelled toward the head by the regular contraction of the chambers of the heart, where it passes out at the open extremities of the arteries and circulates through the body in the loose connective tissue binding the muscular and other tissues together. It also appears to pass from the aorta by osmosis, as there are distinct currents passing from it. It is also found free in the abdominal cavity and in the various glands and digestive organs. As there is no vessel collecting and returning the blood to the heart, it must all be returned to the circulation by entering the cavity of the abdomen by transudation, and then passing into the heart through the valves in its walls.

As the pupa nears maturity, the pulsations of the heart increase in rapidity, reaching the maximum just before the development of the moth is complete, when they again become less frequent. In the fully developed specimen the number of pulsations is from seventy to seventy-five a minute when quiet. When excited the number may increase to one hundred and twenty or more.

The circulation of the blood is very complete, all the tissues and organs being permeated by it. It flows in definite paths through the tissues, yet the blood channels do not appear to be bounded by a layer of endothelial cells, or to show a structure differing in any particular from the connective tissue surrounding them. At various places are dilatations resembling lymph "lakes." After leaving the arteries the blood, apparently, is self-propelling, as the circulation continues with undiminished vigor in detached tissues. Even in the "blood lakes" there is no stagnation or confliction of the currents, the stream continuing to move uninterruptedly.

The respiratory system does not differ materially from that of other insects. The tracheæ are universally distributed; the only place I have as yet failed to find their ramifications is in the scales. The tracheæ do not inosculate, although branches are given off at short intervals from the main trunks. Division of the branches seldom occurs, and they continue of the same size throughout their course; only rarely is one found that is tapering.

The branches of the tracheæ are most numerous in the muscular tissues, and, as the blood moves more rapidly when near these air vessels, I am of the belief that the free oxidation they afford is an important agent in moving the blood currents.

In the attacus moths the wings are formed early in the pupa stage, but remain of embryonic size until the insect has left the pupa-case. The abdomen, on the contrary, is large and its walls are freely supplied with muscular fibers. As soon as the moth has left the coccoon a contraction of the abdominal walls takes place, forcing a portion of the blood into the still plastic wings, resulting in an enormous increase in their size. The scales participate in this enlargement. In a cecropia this increase is about six times, but in attacus (Tela) polyphemus the mature wing is from fifteen to twenty times the size of the embryonic.

The wings are formed of a membrane supported by ribs, or veins and veinlets. The membranous portion consists of an inferior and superior derma, containing regularly arranged rows of quill follicles and an inter-dermal connective tissue, in which lie the air vessels and blood-circulatory channels. The quill follicles are analogous to

the hair follicles of the higher orders. They consist of a tube of a more dense material than the dermal tissue, and appear as short dark tubes imbedded in the derma. At the outer extremity they are straight, but at the inner end are bulbous A cone-shaped opening pierces the bulbous portion, the apex of the cone opening into the canal of the follicle. The veins resemble, in their expansion, the bellows of a camera. They are formed of a greater proportional diameter than the other parts of the wing, and the inner surface presents a series of transverse annular ridges placed close to one another. As the wing of the newly-hatched imago expands, these ridges become separated and draw out until their surface becomes continuous. The ridges are not entirely lost, as they can be distinguished as transverse markings on the veins in the adult wing.

The scales are formed on the same general plan as the wing itself, and consist of a series of parallel, or slightly diverging tubes, composed of annular segments, starting from a common center and affording support to a membranous portion consisting of two external layers held together by connective tissue.

The circulatory fluid is apparently the chief agent in the enlargement of the scales, as this can be produced artificially, by injecting an aqueous solution of eosin into the areolar tissue about one of the main tracheæ. By this means the color of the scales changes to that of the injection. On the contrary, a fluid forced into the air vessels causes an expansion of the wings alone, while the scales remain of their original dimensions.

By injecting the vascular system from the heart the scales are colored and become larger. A cross section of a vein shows its cavity to be occupied by an air vessel supported by a loose areolar tissue. These tracheæ are found in each of the veins and veinlets, and give off numerous small branches which pass out at the sides of the vein and are distributed through the cellular tissue of the membranous portion. These tracheæ never become of capillary size. In the embryonic wing the air vessels are tortuous, but become straight as the wing expands.

On placing a fœtal wing in water made antiseptic by the addition of an equal volume of "Listerine," the scales become larger and

the derma of the "eye spots" expands. As the remaining portions of the wing do not participate in this enlargement, these "eye spots" become convex, frequently appearing as perfect globes.

In reference to the structure of the scales themselves, I can find nothing to confirm the observations of Sir Royston Pigott, that the scales are composed of two plates held together by parallel rows of pillars. If this were the case the line of fracture of the two surfaces would not necessarily be coincident, especially in the macerated scale. In all instances the two surfaces have fractured alike. In no case have I been able to discover an independent fracture of the two surfaces. In this respect the line of fracture of the butterfly scale resembles the diatom fractures as observed by the Hon. J. D. Cox. The line of fracture following the path of least resistance presents a rough outline.

On the contrary, the scale appears to me to be a repetition of the wing itself, a system of tubes supporting a membrane. The quill is hollow and the tubes radiate from it as the sticks of a fan. At the quill end the scale is thicker and the tubes close together, while at the other extremity it is thin and the spaces between the tubes are greater. Some of the ribs apparently stop as they reach the contracted portion of the scale. These, however, form a canal along the thickened edge of the scale. Just at the base the scale becomes too contracted to contain the tubes, which, in consequence, are represented by a series of pillars supporting and strengthening the scale at this point.